

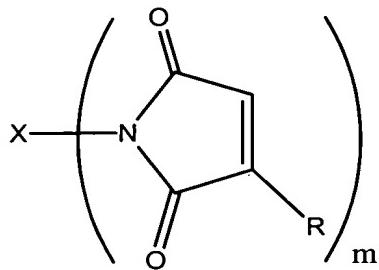
WHAT IS CLAIMED IS:

1. An adhesive composition comprising at least one maleimide-containing monomer, optionally at least one cure initiator, and a plurality of spacers constructed from one or more organic polymers.
2. The adhesive composition according to claim 1, wherein said spacers are substantially spherical.
3. The adhesive composition according to claim 2, wherein said spacers have a particle size in the range of about 0.02 mils up to about 25 mils.
4. The adhesive composition according to claim 3, wherein said spacers have a particle size in the range of about 0.1 mils up to about 15 mils.
5. The adhesive composition according to claim 1, wherein said organic polymers are substantially uncrosslinked.
6. The adhesive composition according to claim 1, wherein said organic polymers are polymerization products of optionally substituted ethylenically unsaturated monomers.
7. The adhesive composition according to claim 1, wherein said organic polymers are polymerization or copolymerization products of α -olefins, (meth)acrylates, vinyl esters, acrylamides, or acrylonitriles.
8. The adhesive composition according to claim 1, wherein said organic polymers are polymerization or copolymerization products of (meth)acrylates.
9. The adhesive composition according to claim 1, wherein said organic polymer is polymethylmethacrylate.

10. The adhesive composition according to claim 9, wherein said polymethylmethacrylate has a molecular weight in the range of about 50,000 up to about 1,500,000.

11. The adhesive composition according to claim 9, wherein said polymethylmethacrylate has a molecular weight in the range of about 400,000 up to about 500,000.

12. The adhesive composition according to claim 1, wherein said maleimide-containing monomer has the following structure:



wherein:

$m = 1-6$,

each R is independently selected from hydrogen or lower alkyl,
and

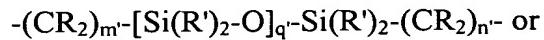
X is a monovalent moiety or a multivalent linking moiety.

13. An adhesive composition according to claim 12, wherein said monovalent moiety or multivalent linking moiety is selected from

(I) straight or branched chain alkyl, alkylene, oxyalkylene, alkenyl, alkenylene, oxyalkenylene, ester, or polyester, optionally containing

substituents selected from hydroxy, alkoxy, carboxy, nitrile, cycloalkyl or cycloalkenyl,

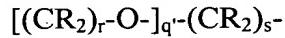
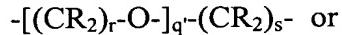
(II) siloxanes having the structure:



wherein

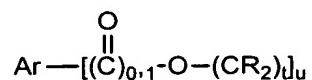
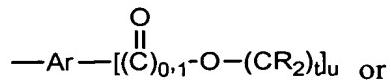
each R is independently defined as above,
and each R' is independently selected from
hydrogen, lower alkyl or aryl, m' falls in the range
of 1 up to 10, n' falls in the range of 1 up to 10, and
q' falls in the range of 1 up to 50,

(III) polyalkylene oxides having the structure:

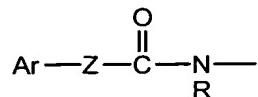
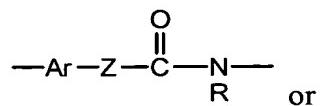


wherein each R is independently as defined above, r falls in
the range of 1 up to 10, s falls in the range of 1 up to 10,
and q' is as defined above,

(IV) aromatic moieties having the structure:



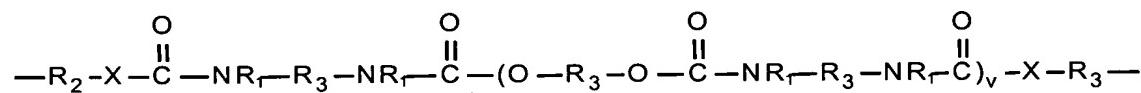
wherein each R is independently as defined above, t falls in the range of 2 up to 10, u is 1, 2 or 3, and Ar is as defined above, or



wherein

Z is O or NR, wherein R is hydrogen or lower alkyl,

(V) urethanes having the structure



wherein:

each R₁ is independently hydrogen or lower alkyl,

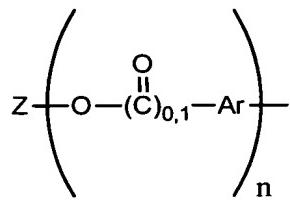
each R₂ independently is an alkyl, aryl, or arylalkyl group having 1 to 18 carbon atoms;

R₃ is an alkyl or alkyloxy chain having up to about 100 atoms in the chain, which chain may contain aryl substituents;

X is O, S, N, or P; and

v is 0 to 50,

(VI) aromatic moieties having the structure:



wherein

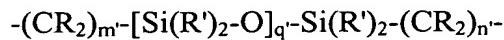
each Ar is a monosubstituted, disubstituted or trisubstituted aromatic or heteroaromatic ring having in the range of 3 up to about 10 carbon atoms,

n is 1 up to about 50, and

Z is selected from:

straight or branched chain alkyl, alkylene,
oxyalkylene, alkenyl, alkenylene, oxyalkenylene, ester, or
polyester, optionally containing substituents selected from
hydroxy, alkoxy, carboxy, nitrile, cycloalkyl or
cycloalkenyl,

siloxanes having the structure:



wherein

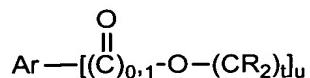
each R is independently defined as above,
and each R' is independently selected from
hydrogen, lower alkyl or aryl, m' falls in the range
of 1 up to 10, n' falls in the range of 1 up to 10, and
q' falls in the range of 1 up to 50,

polyalkylene oxides having the structure:



wherein each R is independently as defined above, r falls in the range of 1 up to 10, s falls in the range of 1 up to 10, and q' is as defined above,

aromatic moieties having the structure:



wherein each R is independently as defined above, t falls in the range of 2 up to 10, u is 1, 2 or 3, and Ar is as defined above,

as well as mixtures of any two or more thereof.

14. The adhesive composition according to claim 1, wherein said cure initiator is a free-radical cure initiator.

15. The adhesive composition according to claim 14, wherein said free-radical cure initiator is a member selected from the group consisting of peroxy ester, peroxy carbonate, hydroperoxide, alkylperoxide, arylperoxide, or azo compound.

16. An adhesive composition according to claim 1, wherein said composition comprises in the range of about 1 wt% up to about 95 wt% at least one maleimide-containing monomer, in the range of about 0.2 wt% up to about 2.0 wt% at least one cure initiator, and in the range of about 1 wt% up to about 95 wt% at least one spacer constructed from one or more organic polymers.

17. An adhesive composition according to claim 16, wherein said composition comprise in the range of about 1 wt% up to about 50 wt% at least one spacer constructed from one or more organic polymers .

18. An adhesive composition according to claim 17, wherein said composition comprises in the range of about 1 wt% up to about 10 wt% at least one spacer constructed from one or more organic polymers.

19. An adhesive composition according to claim 1, further comprising at least one coupling agent.

20. An adhesive composition according to claim 1, further comprising at least one filler different from the spacer constructed from one or more organic polymers.

21. An adhesive composition according to claim 20, wherein said filler is conductive.

22. An adhesive composition according to claim 20, wherein said filler is electrically conductive.

23. An adhesive composition according to claim 20, wherein said filler is thermally conductive.

24. An adhesive composition according to claim 20, wherein said filler is non-conductive.

25. An adhesive composition according to claim 20, wherein said filler is a perfluorinated hydrocarbon polymer.

26. An adhesive composition according to claim 20, wherein said filler is present in the range of about 1 wt % up to about 95 wt%.

27. An adhesive composition comprising in the range of about 1 wt % up to about 95 wt% at least one maleimide-containing monomer, in the range of about 0.2 wt % up to about 2.0 wt % at least one cure initiator, in the range of about 0.5 wt % up to about 5 wt % at least one coupling agent, in the range of about 1 wt % up to about 95 wt% at least one filler, and in the

range of about 1 wt% up to about 50 wt% spacer constructed from one or more organic polymers.

28. A method for creating a substantially uniform bond line between a device and a substrate, said method comprising subjecting a sufficient quantity of an adhesive formulation according to claim 1 positioned between said substrate and said device to conditions suitable to cure said adhesive formulation, wherein said spacers control bond line thickness between said device and said substrate.

29. The method according to claim 28, wherein said bond line thickness is determined by the size of said spacers.

30. The method according to claim 28, wherein said device is a semiconductor die.

31. A method for controlling adhesive gap thickness between a device and a substrate, said method comprising subjecting a sufficient quantity of an adhesive formulation according to claim 1 positioned between said substrate and said device to conditions suitable to cure said adhesive formulation, wherein said spacers control adhesive gap thickness between said device and said substrate.

32. A method for maintaining planarity across an adhesive bond line, said method comprising subjecting a sufficient quantity of an adhesive formulation according to claim 1 positioned between a substrate and a device to conditions suitable to cure said adhesive formulation, wherein said spacers maintain planarity across the bond line between said device and said substrate.

33. The method according to claim 31, wherein said device is a semiconductor die.

34. A method for creating substantially uniform bond lines between at least two semiconductor dice attached to a substrate in a stacked arrangement, said method comprising subjecting a sufficient quantity of an adhesive formulation according to claim 1 positioned

between said substrate and each of said dice to conditions suitable to cure said adhesive formulation.

35. A method for adhesively attaching at least two semiconductor dice to a substrate in a stacked arrangement without the need for a spacer die, said method comprising subjecting a sufficient quantity of an adhesive formulation according to claim 1 positioned between said substrate and each of said dice to conditions suitable to cure said adhesive formulation.

36. A method for controlling bond line thickness between semiconductor dice in an assembly comprising a plurality of semiconductor dice in a stacked arrangement, said method comprising subjecting a sufficient quantity of an adhesive formulation according to claim 1 positioned between each of said dice to conditions suitable to cure said adhesive formulation.

37. An assembly comprising a first article adhered to a second article by a cured aliquot of the adhesive composition according to claim 1.

38. A bond line in an assembly wherein said assembly comprises at least one semiconductor die, at least one substrate, and an adhesive composition positioned therebetween, wherein the thickness of said bond line is determined by a plurality of spacers in said adhesive formulation.

39. A bond line according to claim 38, wherein said bond line is in the range of about 3 mils up to about 6 mils.

40. An adhesive composition according to claim 1, wherein said spacers constructed from one or more organic polymers include at least one reactive moiety.

41. A die-attach paste comprising an adhesive composition according to claim 1, and optionally a filler different from said spacers constructed from one or more organic polymers.

42. An assembly comprising a substrate and plurality of semiconductor dice positioned on said substrate in a stacked arrangement, wherein each of said semiconductor die is adhered to either the substrate or another die by a cured aliquot of the adhesive composition according to claim 1.

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